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Application No. 10/528,362
Amendment dated February 28, 2008
Reply to Office Action of November 28, 2007

Docket No.: 4379-0176PUS1

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method of nitriding a metal ring made of maraging steel, comprising the steps of:

heating the metal ring made of maraging steel in the presence of a halogen compound gas, so as to eliminate an oxide film from the surface of the metal ring and to form a halogenous compound film;

heating the metal ring made of maraging steel on which said halogenous compound film is formed under a vacuum or reduced pressure atmosphere, so as to eliminate said halogenous compound film; and

heating the metal ring made of maraging steel from which said halogenous compound film is eliminated in the presence of an ammonia gas, so as to carry out nitriding;

wherein said nitriding is carried out by maintaining the metal ring made of maraging steel under an atmosphere comprising ammonia at a processing temperature ranging from 450°C to 500°C for a processing time ranging from 30 to 120 minutes, said nitriding comprising the steps of:

placing said metal ring into a heating furnace and raising the temperature inside the heating furnace to said processing temperature;

introducing a first mixed gas comprising 50% to 90% by volume ammonia, 0.1% to 0.9% by volume oxygen, with the residual volume substantially comprising nitrogen, into said heating furnace at the processing temperature, and maintaining the furnace at the processing temperature, thereby forming a nitrided layer on the surface of the metal ring;

replacing the atmosphere inside said heating furnace with a second mixed gas when one-third to one-half of the processing time has elapsed, said second mixed gas comprising 0% to 25% by volume ammonia, with the residual volume substantially comprising nitrogen; and

maintaining the furnace at the processing temperature until the remaining processing time has elapsed.

2. (Original) The method of nitriding a metal ring made of maraging steel according to claim 1, wherein the elimination of said halogenous compound film is carried out by heating

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the metal ring made of maraging steel, on which said halogenous compound film is formed, under a vacuum or reduced pressure atmosphere at a temperature ranging from 450°C to 490°C for 5 to 10 minutes.

3. (Original) The method of nitriding a metal ring made of maraging steel according to claim 1, wherein said halogen compound gas is one type of gas selected from a group consisting of a fluorine compound gas, a chlorine compound gas, and a bromine compound gas.

4.-5. (Canceled)

6. (Original) The method of nitriding a metal ring made of maraging steel according to claim 5, wherein said first mixed gas consists of 50% to 90% by volume of ammonia, 0.5% to 4.5% by volume of air, and a residual volume consisting of nitrogen.

7. (Withdrawn) A nitriding apparatus for nitriding a metal ring made of maraging steel, which heats a metal ring made of maraging steel in the presence of a halogen compound gas to eliminate an oxide film from the surface of the metal ring, and then maintains the metal ring under an atmosphere comprising at least ammonia at a processing temperature ranging from 450°C to 500°C for a processing time ranging from 30 to 120 minutes, so as to carry out nitriding,

said nitriding apparatus, comprising a preheating chamber and a nitriding chamber,

said preheating chamber comprising first heating means for heating the inside of said preheating chamber to said processing temperature when the chamber accommodates the metal ring, halogen compound gas introducing means for introducing a halogen compound gas into said preheating chamber, and first exhausting means for exhausting the atmosphere inside said preheating chamber,

wherein the metal ring is heated by said first heating means in the presence of a halogen compound gas introduced by said halogen compound gas introducing means, so as to eliminate an oxide film from the surface of the metal ring and to form a halogenous compound film, and

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after the formation of said halogenous compound film, the atmosphere inside said preheating chamber is exhausted by said first exhausting means to reduce the pressure in said preheating chamber, the metal ring is then heated by said first heating means under a vacuum or reduced pressure atmosphere, so as to eliminate the halogenous compound film, and after the elimination of said halogenous compound film, the inside of said preheating chamber is heated to the processing temperature by said first heating means, and

said nitriding chamber comprising second heating means for heating the inside of said nitriding chamber to said processing temperature and maintaining the furnace inside at the temperature, nitrogen gas introducing means for introducing a nitrogen gas into said nitriding chamber, ammonia gas introducing means for introducing an ammonia gas into said nitriding chamber, oxygen gas introducing means for introducing an oxygen gas into said nitriding chamber, and second exhausting means for exhausting the atmosphere inside said nitriding chamber,

wherein a first mixed gas consisting of 50% to 90% by volume of ammonia, 0.1% to 0.9% by volume of oxygen, and a residual volume substantially consisting of nitrogen is generated from the nitrogen gas introduced by said nitrogen gas introducing means, the ammonia gas introduced by said ammonia gas introducing means, and the oxygen gas introduced by said oxygen gas introducing means, and the metal ring is transferred from said preheating chamber into said nitriding chamber under the first mixed gas atmosphere, so as to form a nitrided case on the surface of the metal ring,

when one-third to one-half of the processing time has passed, while the first mixed gas is exhausted by said second exhausting means, a second mixed gas consisting of 0% to 25% by volume of ammonia and a residual volume consisting of nitrogen is generated from nitrogen gas introduced by said nitrogen gas introducing means and ammonia gas introduced by said ammonia gas introducing means, and the atmosphere inside said nitriding chamber is replaced by the second mixed gas,

thereafter, the metal ring is maintained in said nitriding chamber under the second mixed gas atmosphere until the remaining processing time passes.

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8. (Withdrawn) The nitriding apparatus according to claim 7, comprising a first combustion device for burning the atmosphere removed from said preheating chamber by said first exhausting means.

9. (Withdrawn) The nitriding apparatus according to claim 7, comprising a second combustion device for burning the atmosphere removed from said nitriding chamber by said second exhausting means.

10. (Withdrawn) The nitriding apparatus according to claim 7, wherein said preheating chamber comprises an door that is established between said preheating chamber and said nitriding chamber and flexibly moves up and down, and that said preheating chamber can be connected to said nitriding chamber through said door.

11. (Withdrawn) The nitriding apparatus according to claim 7, comprising transferring means for intermittently transferring the metal ring from said preheating chamber to said nitriding chamber.